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# FŒHN IN THE ANDES

William Morris

By W. ~~H~~ M DAVIS,

CAMBRIDGE, MASS.

REPRINTED FROM
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Geol.

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# THE FŒHN IN THE ANDES.

BY W. H. DAVIS, CAMBRIDGE, MASS.

During the preparation of a recent article on "Mountain Meteorology," * I took occasion to look over several narratives of travels in Patagonia to see if by chance they contained any account of the Fœhn-like winds that must, without question, occur in the valleys on the eastern slope of the southern Andes, just as they occur on the corresponding leeward slope of the New Zealand Alps, or in the Chinook districts of our western Cordilleras. The search was not successful; but shortly after the publication of the article in question, Mr. A. B. Hart, member of the New England Meteorological Society, called my attention to an account of a hot, parching wind felt near the eastern foot of the Andes at San Juan in the Argentine Republic, as a distinct example of the Fœhn class, easily recognized as such from the description given of it, and from the geographic surroundings so peculiarly fitted for its development. The account is given in the narrative of a remarkable journey—"A thousand miles walk across South America"—by Nathaniel H. Bishop (Boston, 1869). Mr. Bishop was under twenty years of age while on this long walk; he left Boston with $45 and returned with $50.

The wind in question is called the *vente de Zonda;* a name of general application as will be seen below. The following abstract is taken from a brief chapter given to its description. The wind is said to be of local occurrence, blowing only in the vicinity of San Juan, the capitol of a province of the same name, lying on an open plain three or four leagues east of a deep transverse break in the outer Sierra at the eastern base of the Andes. A few farms lie in a valley behind the front range, constituting the hamlet of Zonda, from which the wind is named. "It blows at all seasons, though during July and August (midwinter) it is more frequent. This wind is hot and parching to the skin, and brings with it clouds of dust and fine sand." While it blows, "all persons leave their work, and seek refuge in their houses, while frequently the huts of the Gauchos are blown down by the force of the wind. Most persons are troubled with severe headaches. Those who have been suffering from diseases of the heart find their complaint greatly aggravated, and frequently there are cases of sudden death. The wind lasts sometimes two or three hours; at other times forty-eight hours, though this duration is rare." Bishop noted upward of twenty Zondas in the single winter he passed at San Juan. They end suddenly; a few puffs of cold air from the south announce the change, and immediately after the vane veers from west to south, and a cold wind as strong as the hot Zonda then prevails. All nature is refreshed and men resume their abandoned labors. According to the testimony of the natives of San Juan, the Zonda does not cover a broader space than ten or fifteen miles after it leaves the sierra of Zonda; and it is said not to occur further north.

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* Appalachia, IV, 1886.

The following is a good special description by Bishop: "During the latter part of August as I was standing upon the saline desert, a few miles east of San Juan, my attention was attracted by a cloud of dust that appeared to roll through the air as it approached me. I started for a shelter, and had hardly reached it when the Zonda swept past, filling the air with fine yellow sand. The temperature of the previously sultry atmosphere suddenly rose many degrees, and the occupants of the neighboring huts were affected with severe headaches. I noted with a compass the course of the wind, which was west. All night and through the following day and night, the wind continued blowing with undiminished force. Each hour the vane beside the hut was consulted, and the same course as at first was always observed. A few hours before the wind ceased the sand showers were exhausted. The greatest heat was during the first few hours; and this is always the case if the Zonda commences during the day. After continuing thirty-six hours the change came. It was instantaneous. The hot wind seemed cut off at right angles by a cold wind from the south. The change could not have occupied more than forty seconds. The south wind lasted twenty hours and was as violent as the hot Zonda."

"The most important question is, where originate the hot and parching wind that always accompanies and is peculiar to the Zondas? The old guides, who are familiar with the valleys of the Andes, informed me that these winds blow off from the main snow-clad ridge of that great chain of mountains, and expressed their surprise at the fact 'that from a cold region comes a burning wind.'". Bishop is inclined to follow Miers, an earlier observer, in attributing the wind to a volcanic source.

John Miers, to whom Bishop refers, wrote an account of his "Travels in Chili and La Plata" (London, 1826,) and at page 283 of the first volume, he gives the following description for Mendoza, lying east of the front range, about one hundred and fifty miles south of San Juan:

"I may here mention the hot hurricanes, which, blowing from this [Sonda] valley, have acquired the name of Sonda winds, the pest of Mendoza during the summer time. Whenever these winds happen to blow in Mendoza, everybody is seen running into their houses; the doors and windows of every habitation are closely shut, and the inmates light candles, as if the night was come. The wind is a perfect hurricane, often doing much mischief to the chacras [Indian cabins] and orchards; the atmosphere is clouded with dust and sand raised by the wind; the air feels hot and scorching, like a violent blast from a furnace; in the course of a few minutes, the thermometer has been known to rise twenty degrees; the heat, indeed, is insufferable, and brings pestilence with it. It proceeds from some place more northerly than San Juan; that town is also more visited by these winds than Mendoza, for it sometimes happens that they scarcely reach the latter place. They seldom continue to blow more than a day." When speaking of showers of sand, he says, "It

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the region of the high Cordillera; well situated therefore for feeling winds descending from the mountains.

I next consulted the works of Dr. B. A. Gould, who as director of the National observatory and of the Meteorological office of the Argentine Republic at Cordova had opportunity of gaining a wide knowledge of Argentine meteorology. He briefly describes the Zonda as the "South American Sirocco." (Anales de la Oficina Meteorológica Argentina, iii, 1882, 329.) This will doubtless determine the use of "Zonda" chiefly for a hot, dry, northerly wind of some strength on the Argentine plains; but it does not touch the question of fœhn-like winds in the neighborhood of the mountains.

Observations for San Juan and Mendoza have as yet been published only in brief summaries in the *Anales*, so that I cannot now attempt a comparison of Bishop's and Miers' descriptive accounts with the matter-of-fact thermometric records.

The isothermal chart in the third volume of the *Anales*, on which the reduction of temperatures to sea-level has been applied, shows a southward loop of the lines of mean annual temperature east of the Andes. Dr. Gould, commenting on this says: "The reduced temperature seems to increase distinctly in the neighborhood of the large Sierras; a fact for which it would not be difficult to offer explanations founded on geological considerations" (Anales, iii, 505). It seems likely, however, that some of this local warmth is due to descent of winds from the mountains.

Two of the observers, Srs. Schickendantz and Hüniken, whose records were discussed in the *Anales* under Dr. Gould's direction, make frequent mention of the Zonda winds in their notes; and the situation of their stations in relation to adjacent mountain ranges suggests that some of these Zondas may be Fœhns. The following details are therefore presented:

Sr. Don F. Schickendantz, in charge of copper-smelting works at Pilciao, in the province of Catamarca, (latitude 27° 36′ S., longitude about 66° 30′ W.), gives explicit account of the Zonda at his station, from which the following free translation is condensed: Pilciao lies in the northeastern corner of a depression, called the "Campo de Andalgalá"; the mountains rise four leagues to the east, and continue northward in the great Sierra de Aconquija. The eastern slopes of this range in the Province of Tucuman receive sufficient rain from the "vapors of the Atlantic," but its summits "are impassable to the clouds." In the cold months (May to Septembar), Pilciao has practically no precipitation. "It is generally in August that northeast winds begin to blow, commonly lasting from mid-day to sunset; but I have known Zondas, as these winds are called, that maintain the violence of a hurricane for three days and nights. The origin of the Zondas has an easy explanation: the air of the plains, warming with the return of summer, rise on the slopes of the Aconquija, condensing their vapors to precipitate them on the lower levels, and passing over the Sierra where it offers the least obstacle, they fall in the direction of Pilciao. At Pipanaco, eight leagues to the south-east, the Zondas are hardly known." (Anales, iii, 1882, 59).

The following extracts from the records of Pilciao in 1873 seem to confirm the opinion that the winter Zonda there is rather a Fœhn than a Sirocco.

| Date, 1873....... | Temperature, C. | | Rel. Hum. | Wind, Scale 0-4 | |
|---|---|---|---|---|---|
| | Mean daily | Max. | | Direction. 7a. 2p 9p. | Mean force |
| Mean for July | 8.°53 | — | 52.6 | — | 0.7 |
| July 31............ | 18.1 | 34 1 | 28.3 | E NE calm. | 1.3 |

This last day of July had the only northeast wind, the highest mean daily force of wind, the maximum temperature, the highest mean daily temperature and the lowest mean relative humidity of the month.

| | | | | | |
|---|---|---|---|---|---|
| Mean for Aug | 13.49 | — | 46.2 | — | 0.8 |
| Aug. 2............. | 22.6 | 36.8 | 22.7 | S NE S W | 2.0 |

Excepting that northeast winds are recorded several times in August, the second of this month has the same extreme characteristics as in the case given above. At 2 and 9 P. M. the temperatures were 35.7 and 27.5, and the relative humidity was "zero." The next month is different:

| | | | | | |
|---|---|---|---|---|---|
| Mean for Sept | 19.99 | — | 33.9 | — | 1.2 |
| Sept. 20......... | 27.9 | 38.3 | 21.7 | N NE SW | 2.3 |

Here, the wind-force, the mean temperature and the maximum have their highest values for the month, but there are several other days with lower relative humidity. A note opposite the the 20th briefly says "terrible zonda from the west during the night."

| | | | | | | |
|---|---|---|---|---|---|---|
| 1877. | | | | | | |
| Mean for Aug | 13.42 | — | 54.7 | — | 0.5 | |
| Aug. 23.......... | 22.0 | — | 24.3 | calm ne ne | 2.0 | |

This repeats the case of August 2, 1873.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1878 | | | | | | |
| Mean, June... | 9.14 | — | 54.1 | — | 0.9 | |
| June 1. 7 a... | 25.3 | — | 5. | SE | 2. | |
| June 1. 2 p... | 31.2 | — | 5. | SE | 2. | |
| June 1. 9 p... | 21.7 | — | 26. | SW | 2. | |

The mean temperature of this extraordinary day was 26.1 and the mean relative humidity was 12.0! The mean temperatures at 7 A. M., 2 P. M. and 9 P. M. for the month were 1.60, 17.71, 8.11. Schickendantz refers to this heat as a "strong Zonda from the south;" indeed he applies the name to all strong winds, but principally to those from the north. Dr. Gould, in commenting on this, supposes that the name so often employed in the Andine provinces, refers rather to the character of the wind than to its compass-point, and that it is more or less equivalent to the Italian Sirocco (Anales, iii, 389).

Pilciao is so far north that its winds are probably supplied in greatest part from a branch of the trade-winds which turns southward to avoid the Andes: its position southwest of the Sierra of Aconquija is therefore favorable to the development of fœhn-like conditions, whenever the northeast current of air over the mountains is strengthened. The first, second and fourth of the examples quoted above seem to be of this character: the explanation of the other two does not appear, unless they are of the Sirocco kind.

Sr. Don E. Hüniken, mining engineer at Escaleras, furnishes records for this station at the eastern foot of the Sierra de Famatina, one of the outer ranges of the Cordillera in the province of Rioja, (latitude 28° 56′ S., longitude about 68° 15′ W.) He notes that the winds generally follow the east and west ravine at Escaleras, changing direction "al alba y á la oracion" — at dawn or sunrise and at sunset — with great regularity, blowing down stream (from west) by night and up stream by day. Here and in all the valleys of the Cordillera of the Andes, these constant winds are called "*terrales.*" "The variations from these directions are caused by the influence of the strong winds from the north, *Zondas*, which are very frequent in the Andine provinces" (Anales, iii, 113). In the tables containing Hüniken's observations, *Zonda* stands in the column of notes opposite certain dates when the temperature is by no means very high for the season, and in a few cases when the mean for the day is *lower* than the mean of the month, thus adding to the many meanings of this loosely defined term. The following data will illustrate some of the warm and dry Zondas in early winter:

| Date, 1874. | Temperature, C° Mean daily. | Rel. Hum. | Wind, Scale, 0–4 Direction. | | | Mean force | Notes |
|---|---|---|---|---|---|---|---|
| | | | 7 a m | 2 p m | 9 p m | | |
| Mean, June.. | 5.52 | 60.0 | —— | —— | —— | 1.0 | |
| June 9.......... | 13.6 | 27.0 | N W | N N W | S E | 2.0 | Strong Zonda, |
| " 10.......... | 11.9 | 44.3 | N | N | S E | 1.8 | Zonda [2 p m |
| " 22.......... | 5.0 | 57.3 | N N W | N N E | Calm. | 1.3 | Zonda |
| " 25......, .. | 10.0 | 21.7 | N W | N N W | N W | 2 0 | Zonda |
| " 27.......... | 13.6 | 12.7 | N | N | Calm. | 1.8 | Zonda |

The "Zonda" of the 22d was a little below the mean temperature of the month, nearly up to the mean relative humidity, and but little above the mean force of the wind: evidently, direction is the only characteristic of the term as here used. But among these Zondas, it seems very likely that the warmer and dryer ones may deserve placing with the Fœhn winds. Escaleras is however too far north to gain much wind from the Pacific slope, and is therefore not so good a fœhn station as will be found farther south.

The later volumes of the Cordoba *Anales* will doubtless furnish information by which the questions here raised may be definitely settled, especially if stations are found south of Mendoza and near the mountains.

The derivation of the name, Zonda, as given by Bishop, seems to be justified by the maps in Miers' "Travels" and in Burmeister's "Description Physique," on both of which "Zonda"—in one spelling or another—is printed in proper position as the name of a town west of San Juan. But it is not clear how the name thus early localized was afterwards extended all over the open country to the east.

The upshot of the foregoing is, in the first place, that one must not trust very closely to the popular name of a wind as indicative of its origin; and, in the second place, that the warm winter winds at San Juan, and probably at Pilciao also, are true Fœhns, quite distinct from the summer Zonda, or Siroccos of Mendoza, Cordova and San Luis. The account given by Bishop is indeed a very crude one, being without instrumental observations; but it bears good internal evidence of being correct as far as it goes. Perhaps the most interesting part of the description is the one in which meteorology, like history, repeats itself. The hot wind that surprised the people of San Juan by coming down from a cold mountain range is a repetition of the old Swiss puzzle, in Switzerland, the early explanations referred the heat of the Fœhn to a hot source, the Sahara; and Bishop naturally ascribed the heat of his Zondas to a volcano. The local, dynamical origin of the heat in the compression of the descending air is always a later suggestion.

The cold wind following the winter Zonda, as described by Bishop, shows that it is more nearly related to our Chinook than to the Swiss Fœhn, and this might have been anticipated from the similarity of geographic conditions in South and North America. Professor Loomis has shown (Amer. Journ. Sci., 1875, x, 12; 1880, xxii, 13) how the warm west wind at Denver is connected with the passage of a cyclonic storm centre to the north, after which the "cold wave" comes down across the plains of eastern Montana and Wyoming from the British possessions. At San Juan, the cyclonic storm-centre must pass to the south, where storms are known to be frequent in winter, giving the west wind, locally modified into the Zonda, on its northern (equatorial) side, and followed by a cold, south wind from the plains of Patagonia.

The Fœhn, Chinook and Zonda, with other winds of similar origin and characteristics, may all be classed together under the generic term, *Fœhn.* They are all members of the cyclonic indraft, although doubtless sometimes connected with gradients not clearly cyclonic, and therefore come under the broader heading of storm winds, as distinct from the general or planetary winds, the continental monsoons, the littoral land and sea-breezes, the topographic mountain and valley winds; and they are to be distinguished from other members of the cyclonic indraft by the fact that their temperature is raised and their relative humidity is lowered by the local reactions called forth by mountain ranges or plateaus in their geographic path. An unusually hot wind, owing its heat to having come from a hot region in lower latitude might be called a Sirocco after the familiar Italian type: but this needs differentiation, as the Italian Sirocco is sometimes moist, sometimes dry, though always hot. The common Argentine Zonda is a dry Sirocco. In New England, we have an approach to the moist Sirocco in the winter, when the pressure is high in the south, and a cyclonic storm stands central over the lakes: thus in December, 1886, the general maximum in New England for the month (about 50°) occurred at midnight Christmas evening, in such a Sirocco wind, with increasing cloudiness and humidity, and finally with heavy rain. Such a wind is quite distinct from winds of the Fœhn class, inasmuch as its temperature falls and its relative humidity increases as it flows into cooler latitudes. If it pass over a transverse mountain, it may develop Fœhn characteristics in a high degree.

CAMBRIDGE, MASS., February, ~~1877~~.
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